

A Generic Coupler for Data Registration, Match, and Model Coupling

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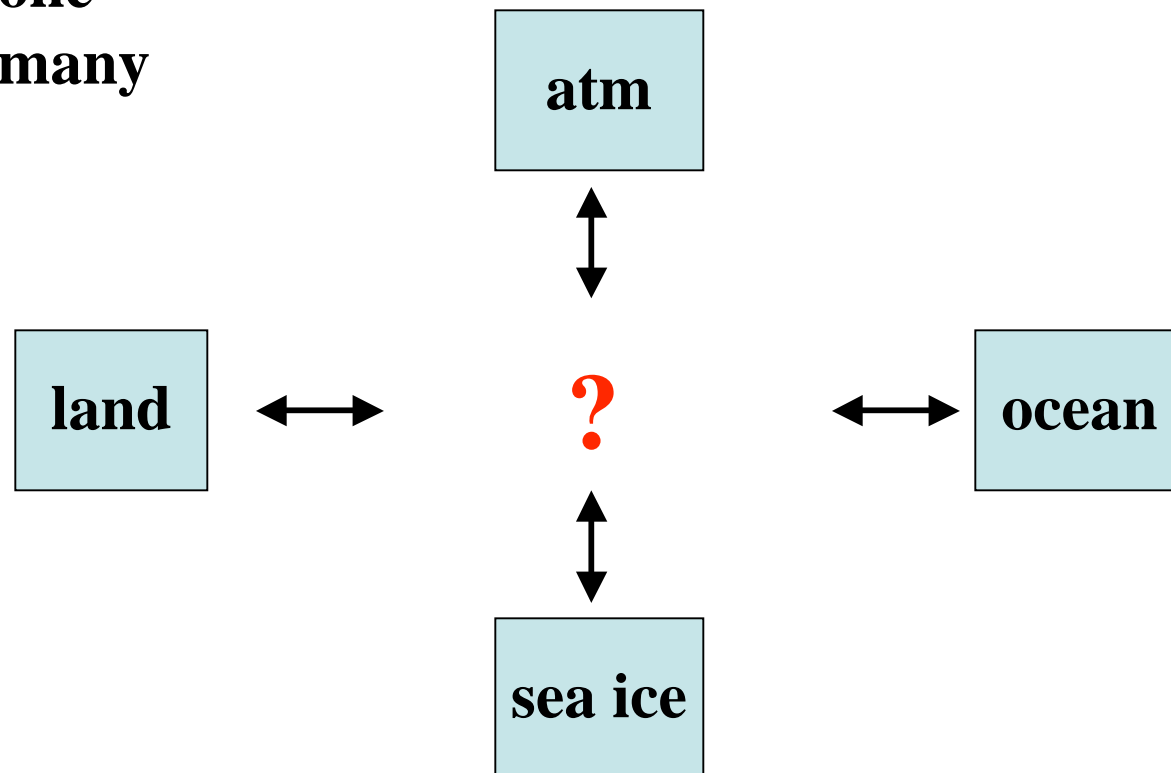
Outline

- Background in Earth system model coupling via components
 - A tool is needed to reduce **complexity** in coupling among **hierarchical** components
- Generic Coupler
 - Architecture
 - Current capabilities
- Summary
- Next step

Earth System Model Coupling

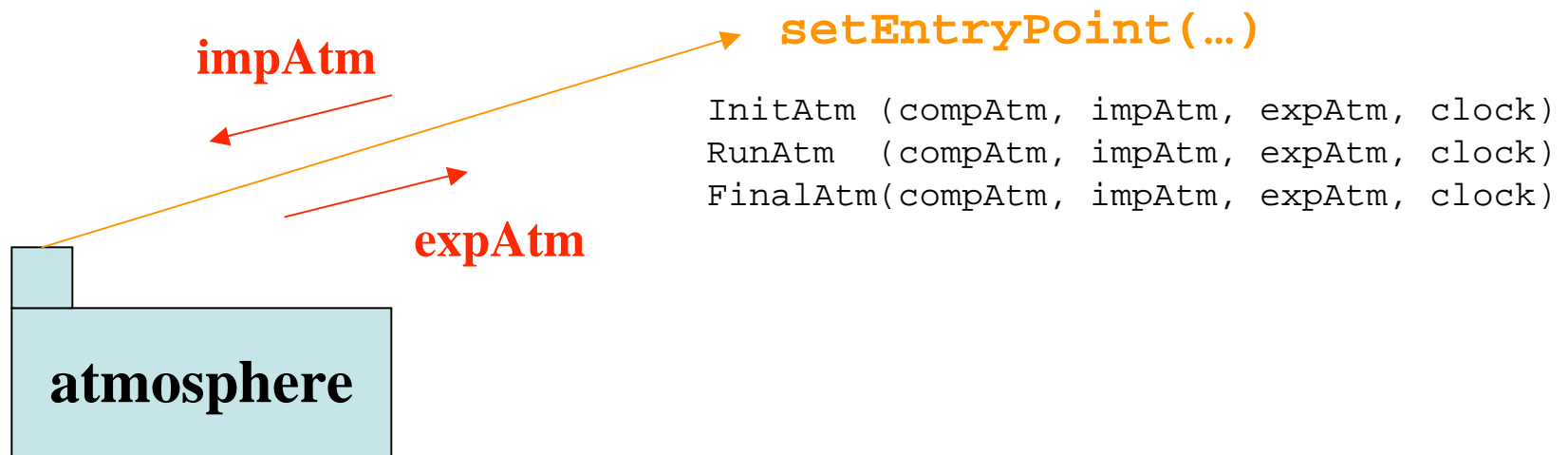
- **Several ways of coupling**

- **Many to one**
- **One to one**
- **One to many**



ESMF Component and State

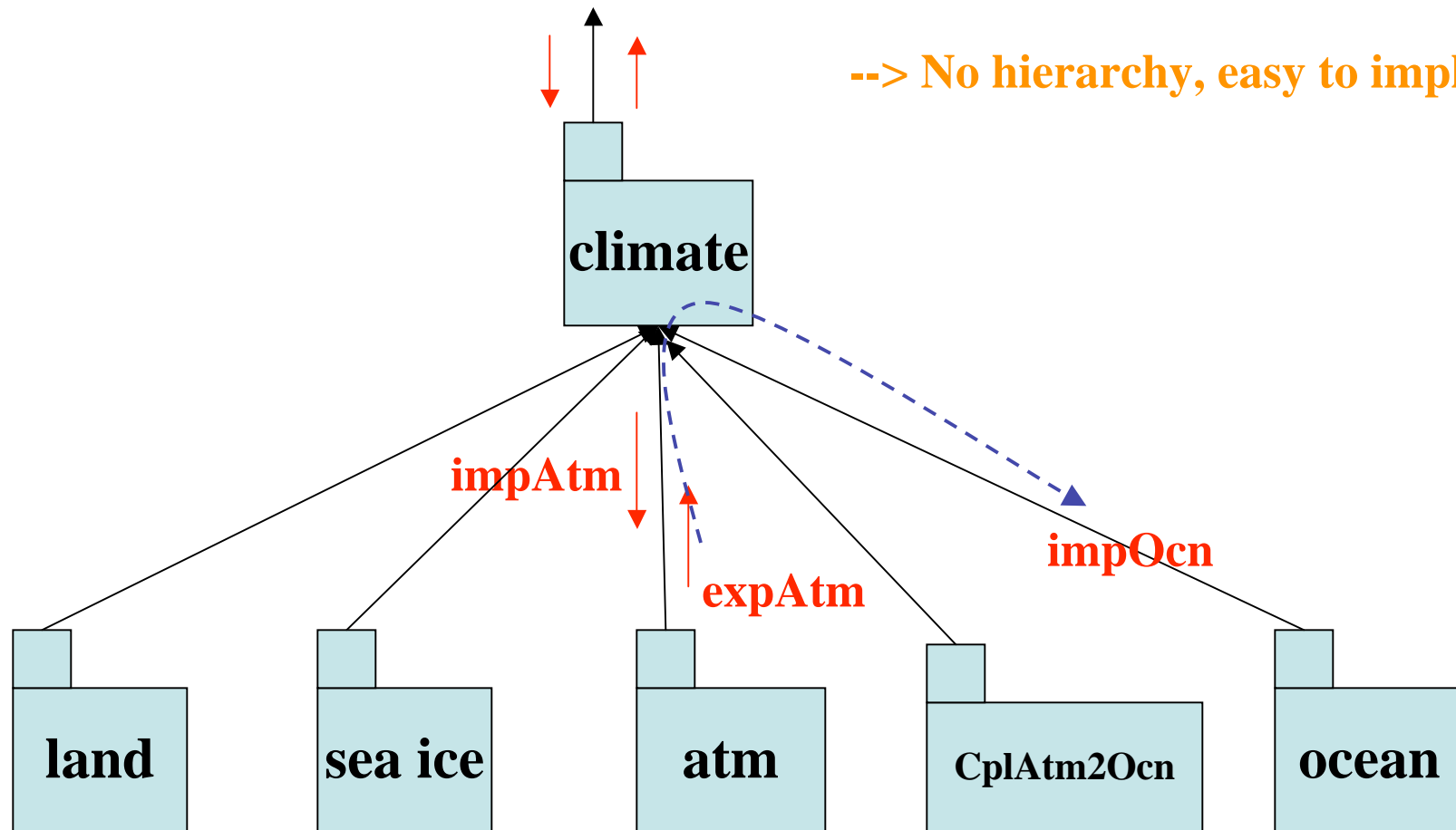
- An ESMF model component should be developed independent of other components
 - Its functions are “**producer**” only while its data are “**producer**”(export) as well as “**consumer**” (import)
- Couplers resolve all the mismatches to ensure model components to interact



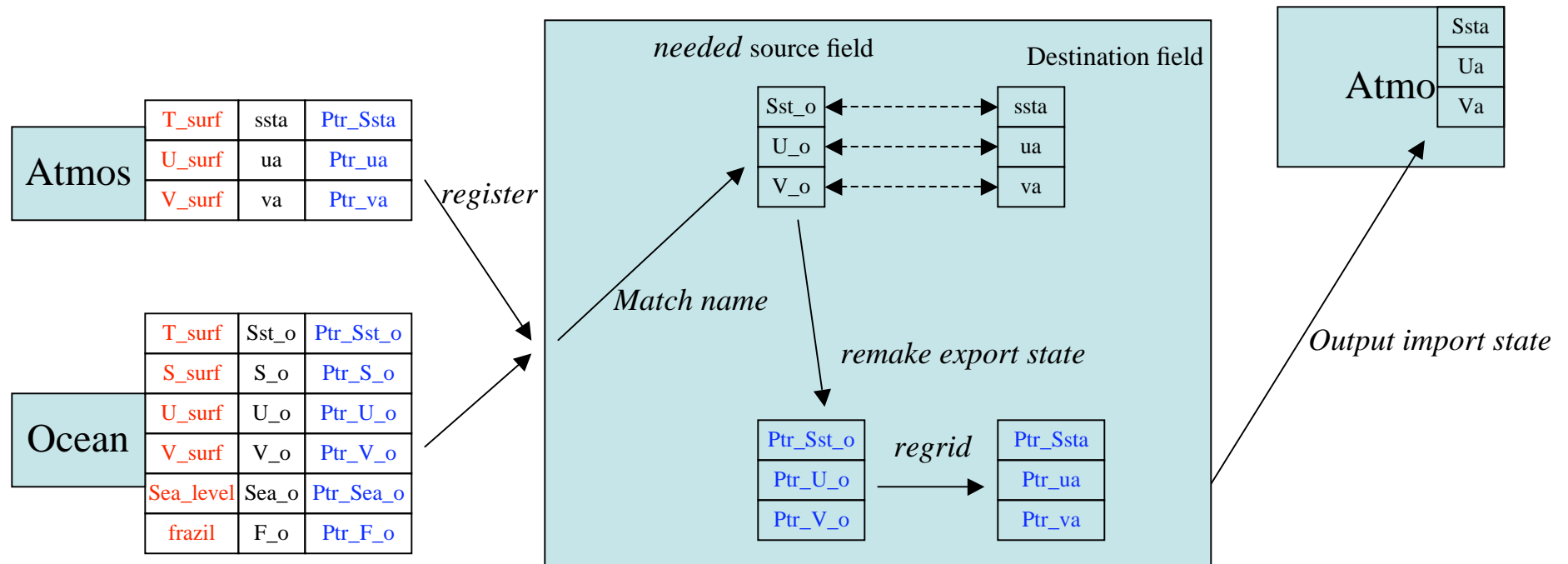
ESMF Component, State, Coupling

At the parent level, atm, land, ocean, sea ice are coupled

--> No hierarchy, easy to implement

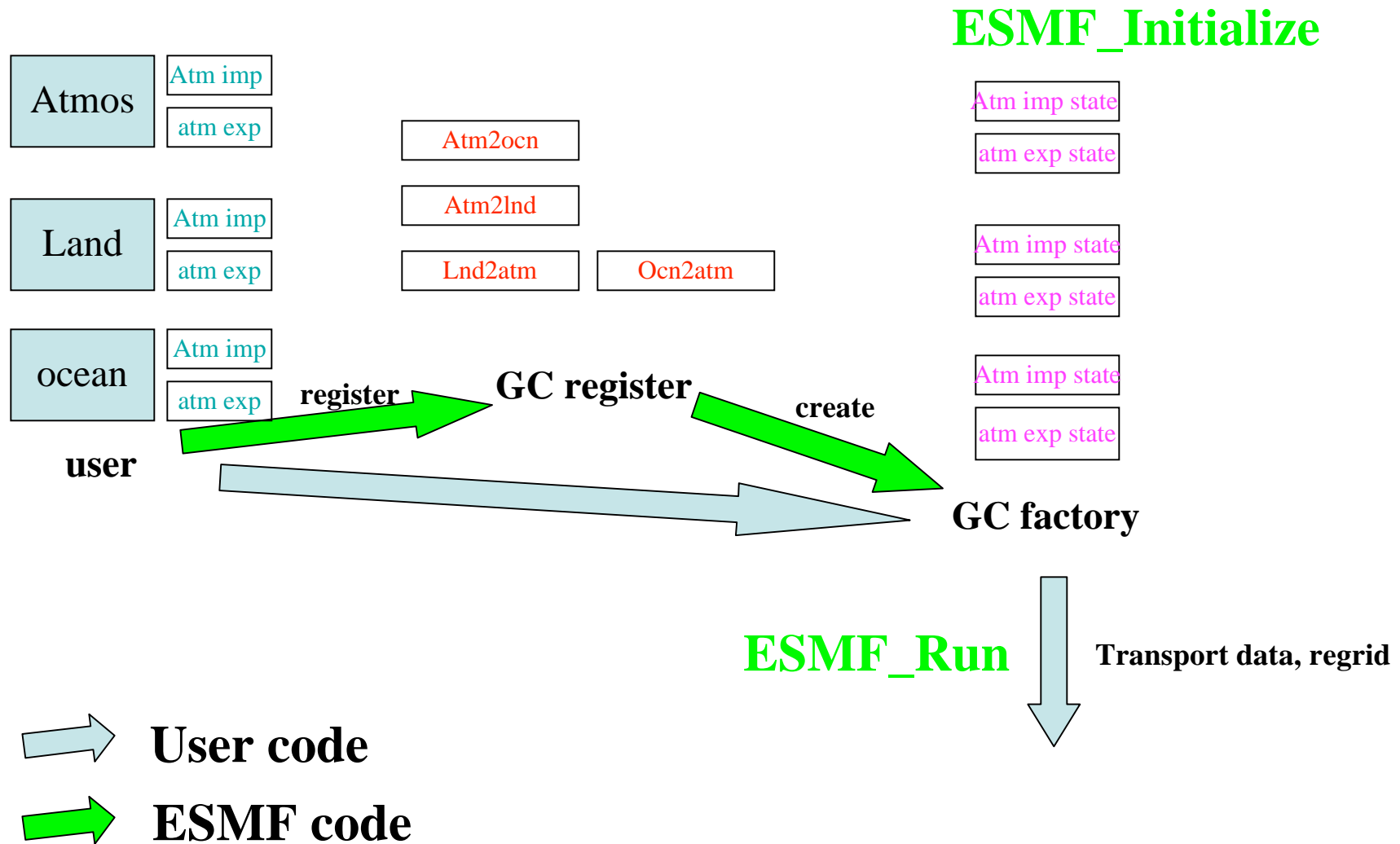


Generic Coupler: Standard Name (e.g., CF) in Coupling



Presented in the ESMF Community Meeting, MIT, August 2005

Generic Coupler



Presented in the conference of Parallel Computational Fluid Dynamics 2005

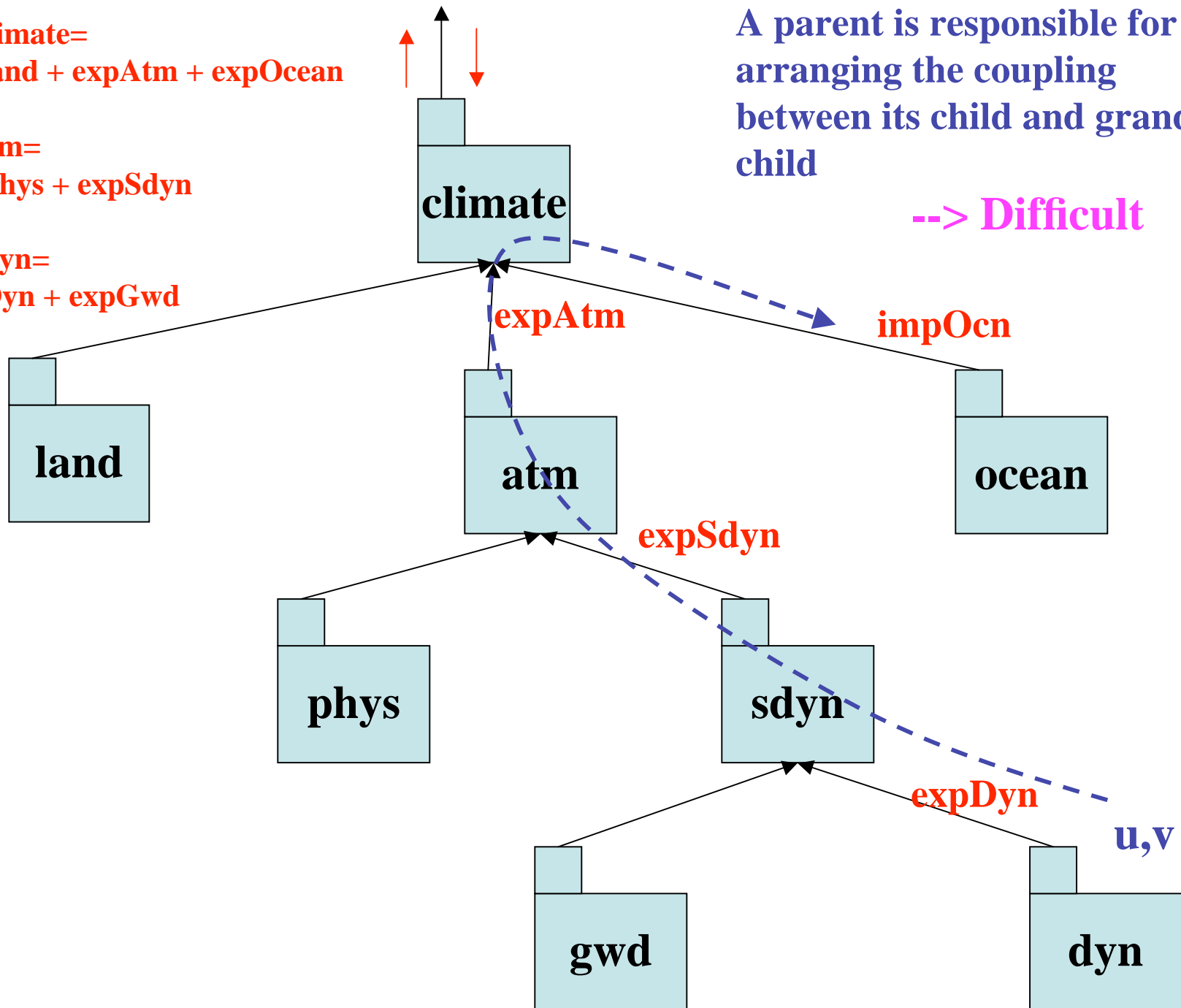
$\text{expClimate} = \text{expland} + \text{expAtm} + \text{expOcean}$

$\text{expAtm} = \text{expPhys} + \text{expSdyn}$

$\text{expSdyn} = \text{expDyn} + \text{expGwd}$

A parent is responsible for arranging the coupling between its child and grand child

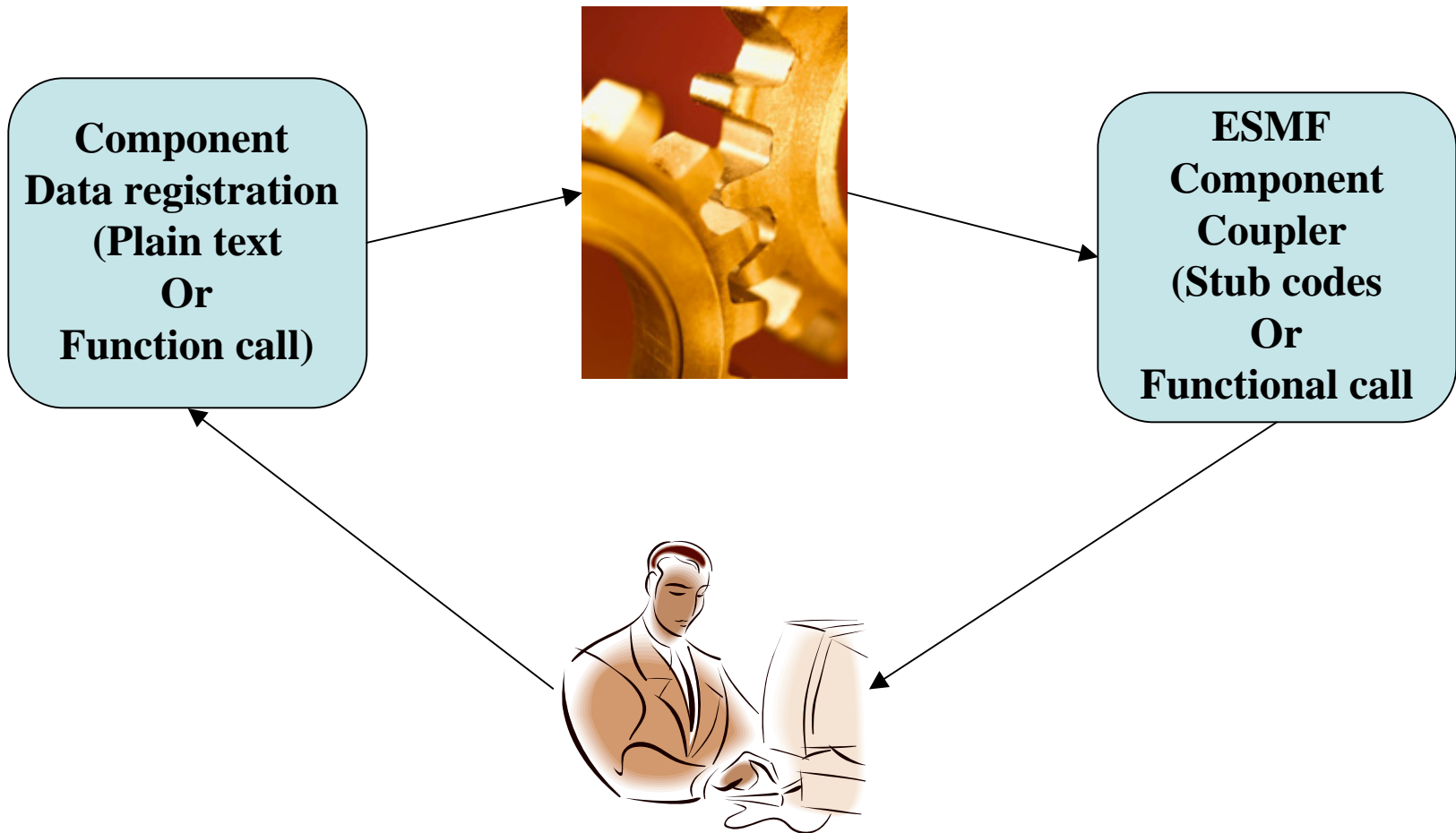
--> Difficult



ESMF Component Coupling

- Coupling tasks
 - An export variable of a component (1) matches, (2) transports, and (3) transforms (if needed) to an import variable of the other component
- ESMF utilities
 - ESMF State is used to contain those variables and perform match
 - `ESMF_StateAddNameOnly(exportState, "U", rc)`
 - `ESMF_StateIsNeeded(importstate, dataname(I), rc)`
 - Nested ESMF State is used to deal with coupling with multiple components
 - Nested ESMF component is used to deal with hierarchy component
 - ESMF coupler is used to deal with the variable transformation such as regridding and unit conversion.

New Generic Coupler



ESMF Component Coupling: Match

- “Match” task
 - *Generic Coupler* does it outside the user code directly with the string matching

ESMF Component Coupling: Transport

- “Transport” task
 - If there is no need for transformation, then assigning the export variable to its matched import variables via pointers or copies.
 - If there is a need for transformation, then ESMF state and coupler are needed.
 - A ESMF component needs to use nested ESMF state to contain all the matched export variables of its children component
 - *Generic Coupler* uses a tree data structure

ESMF Component Coupling: Coupling

- If an export variable of a component (e.g., “DYN”) has been matched to an import variable of the other component “OCN” and transported to the grand parent (e.g., “ATM”) which is the sibling to the component “OCN”.
 - A coupler is needed to transform the variable as needed via regrid and unit changes etc.
 - To ensure flexibility, *Generic Coupler* provides the stub code for users to customize.

Input For *Generic Coupler*

- One input plain text file
 - component name
 - import field name
 - export field name
 - child component name
 - parent component name
 - local name
- Advantage
 - Easy-to-use
 - Less intrusion
 - Dynamic configuration

Example with AGCM of GEOS5

```
componentstart
AGCM
childstart
SDYN
PHYS
childend

parentstart
GCM
AANA
parentend

importstatestart
DUDT
DVDT
DTDT
DPEDT
DQVDT
DO3DT
importstateend

exportstatestart
DUDT_ANA
DVDT_ANA
DTDT_ANA
DPEDT_ANA
DQVDT_ANA
DO3DT_ANA
QVFILL
O3FILL
TROPP
TROPT
TROPQ
exportstateend
componentend
```

Output of *Generic Coupler*

- All the connections from the matched export to import field names
 - Create the stub code of ESMF components with matched import/export field variables
 - Diagram the connection relationship automatically
- The connections can be filtered with the information of component hierarchy tree
 - Only the couplers between the siblings will be created
- The component has the import/export field names of its child components

Use of *Generic Coupler*

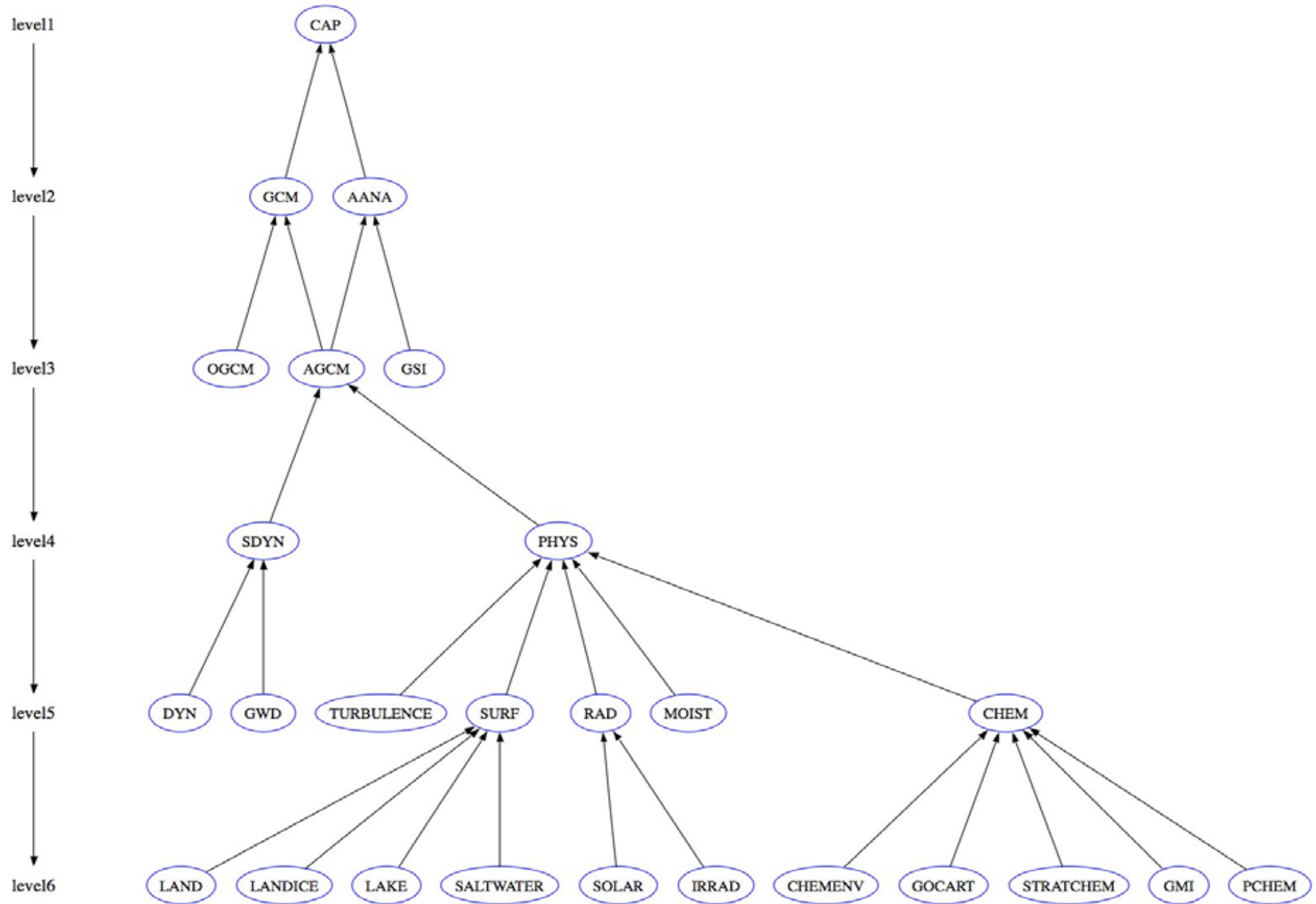
- **To run**

- `gc.exe inputFile outLogFile outConnectFile
selectComponent`

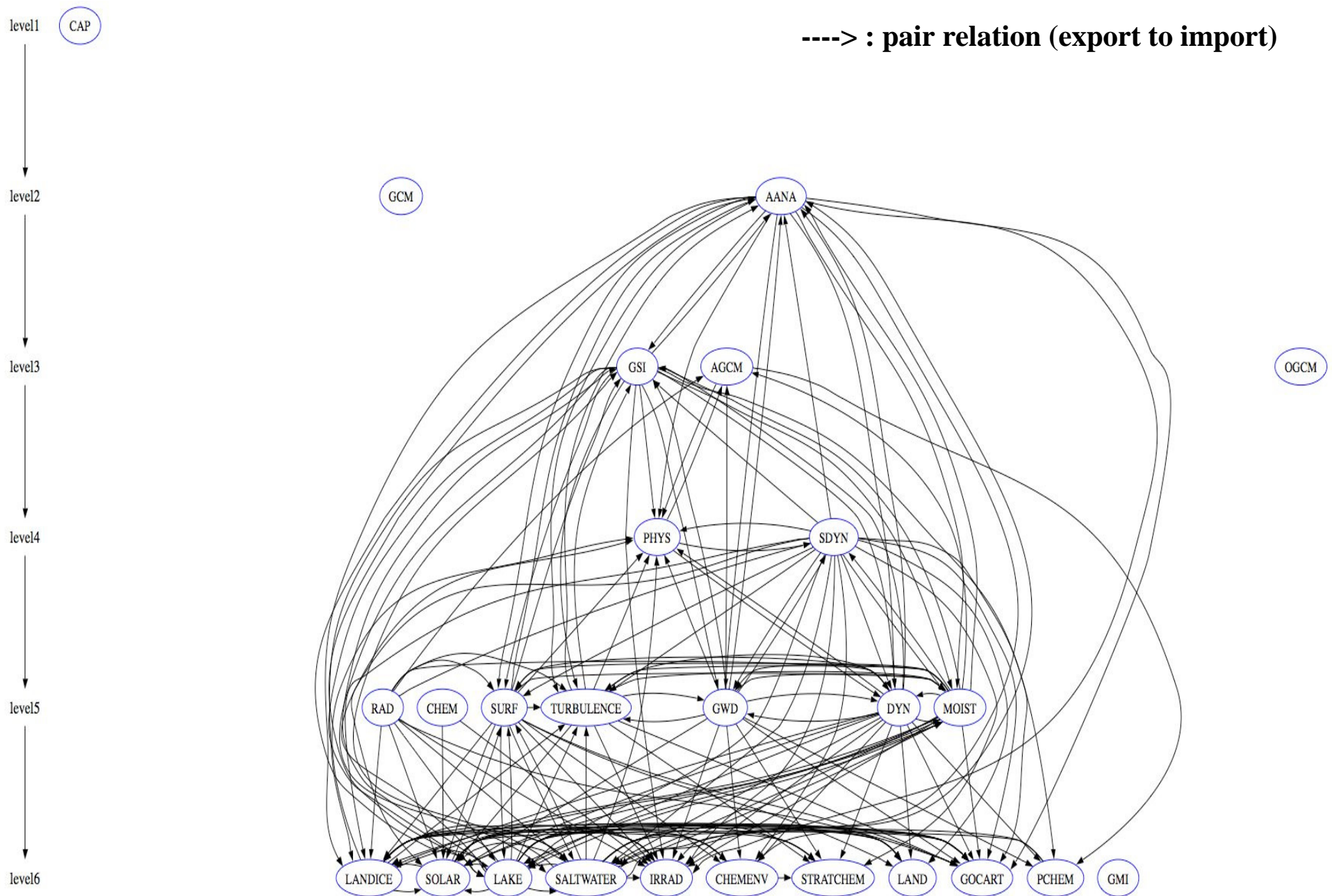
- **To create a connection diagram**

- `dot outConnectFile.dot -Tjpg > outConnectFile.jpg`

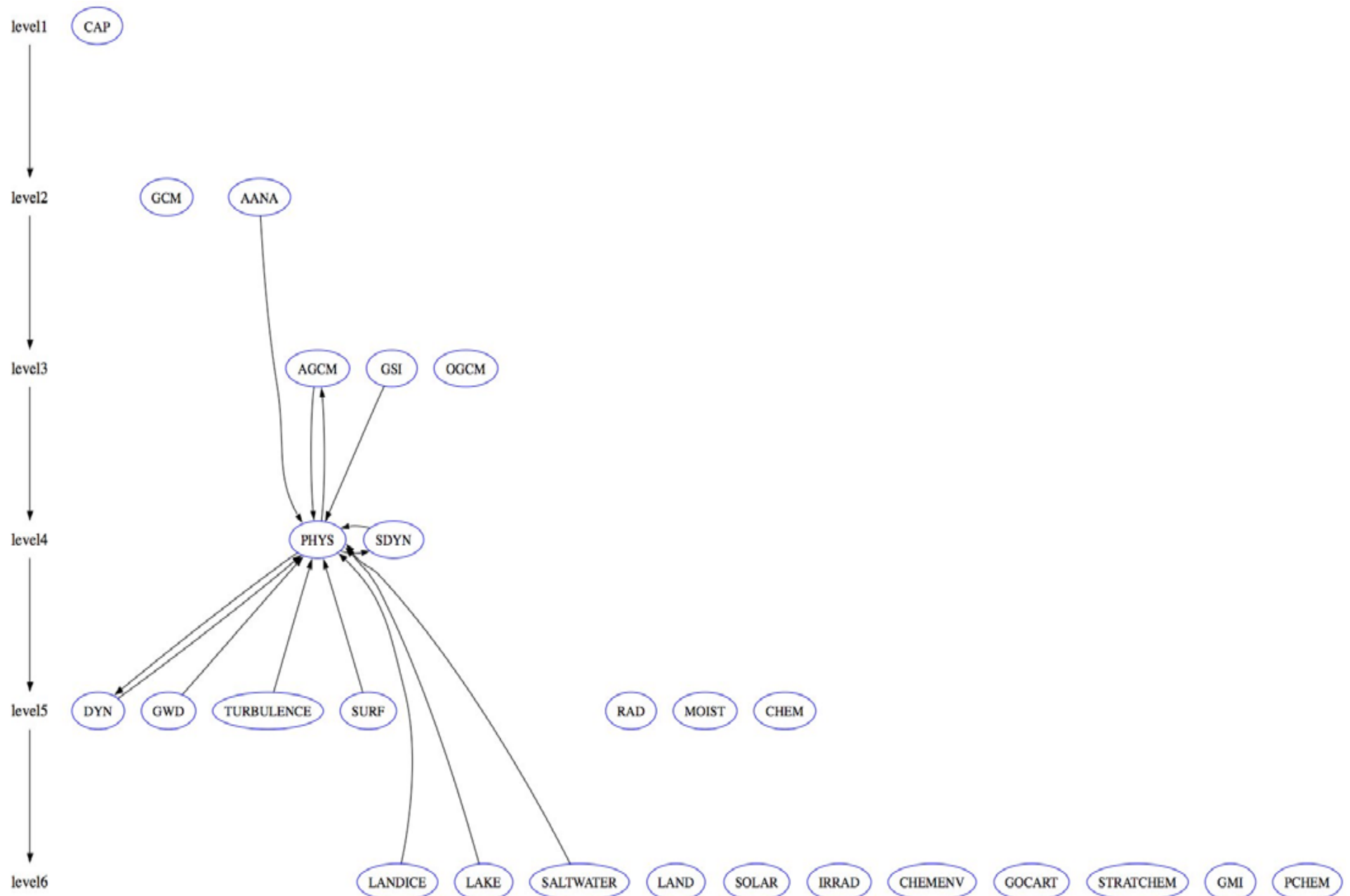
Component Hierarchy Tree in GEOS-5



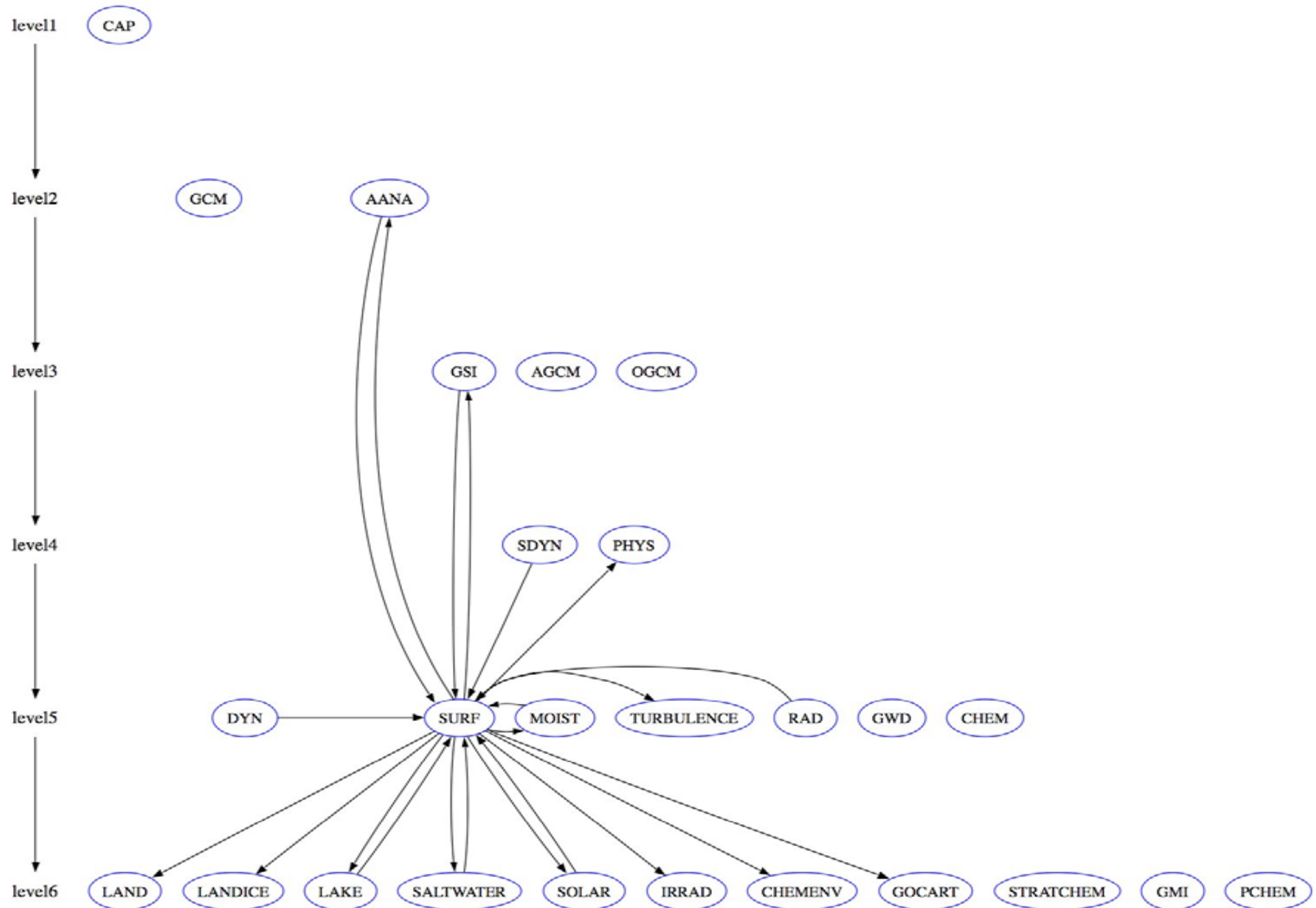
Partial Component Export-To-Import Pair Relationship in GEOS-5



Component Export-To-Import Pair Relationship in **PHYS** of GEOS-5



Component Export-To-Import Pair Relationship in **SURF** of GEOS-5



ESMF Component Stub Code (Sample): AGCM

```
module AGCMMod

    use ESMF_Mod
    public AGCM_register

! Arrays
    public: TROPP, DPEDT, DTDT, DUDT, DVDT

! Fields
    type(ESMF_Field), save:: field_TROPP, field_DPEDT,
    field_DTDT, field_DUDT, field_DVDT

    contains

!-----
```

Only those matched field variables are created.

ESMF Component Stub Code (Sample): AGCM (Continued)

```
subroutine AGCM_register(comp, rc)

type(ESMF_GridComp), intent(inout):: comp
integer, intent(out) :: rc

ESMF_GridCompSetEntryPoint(comp, ESMF_SETINIT, AGCM_init1, 1, rc)
ESMF_GridCompSetEntryPoint(comp, ESMF_SETRUN, AGCM_run, ESMF_SINGLEPHASE, rc)
ESMF_GridCompSetEntryPoint(comp, ESMF_SETFINAL, AGCM_final, ESMF_SINGLEPHASE, rc)

end subroutine

subroutine AGCM_init1(gcomp, importState, exportState, clock, rc)

type(ESMF_GridComp), intent(inout):: gcomp
type(ESMF_State), intent(inout):: importState, exportState
type(ESMF_Clock), intent(in):: clock
integer, intent(out) :: rc

ESMF_StateAddField(importState, field_DPEDT, rc)
ESMF_StateAddField(importState, field_DTDT, rc)
ESMF_StateAddField(importState, field_DUDT, rc)
ESMF_StateAddField(importState, field_DVDT, rc)

ESMF_StateAddField(exportState, field_TROPP, rc)

end subroutine AGCM_init1
```

No more matching for field variables

Summary

- A data registration and match tool has been developed to facilitate ESMF component coupling, in particular coupling among hierarchical components
 - Generate ESMF stub codes of components and couplers
 - Generate diagrams showing the export-to-import pair relationship among components.

Next Step

- User interface will be refined with the feedback
 - Input text file
 - API
- Assemble components and execute
 - CCA-style?

